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ART. I.—*Observations on Wounds of the Internal Jugular Vein and their Treatment, with Special Reference to the Safety of the Ligature; embracing a Statistical Account of Eighty-Six Cases, with some Remarks upon the General Applicability of Ligation as a Venous Hemostatic Agent.* By S. W. GROSS, M. D., late Surgeon and Brevet Lt.-Col. U. S. V.

IN the January number of this Journal the consideration of wounds of the internal jugular vein was brought to a close by a brief examination of the cases of simultaneous injury of that vessel and the carotid artery, resulting in the formation of arterio-venous aneurism. There is, however, one example of aneurismal varix, which occurred in the practice of M. Joret, of Vannes, in 1835, which deserves special mention, as it presents the very interesting peculiarity of a pistol-ball becoming encysted in the vein.

A man, 35 years of age, was wounded in a duel on the 2d of May, 1835, the missile, a small pistol-ball, having traversed the right side of the face and entered the neck behind the left tonsil, where it could be readily detected, but resisted all efforts at extraction by the mouth. Four days subsequently the wound had suppurated, and the ball had disappeared. A pulsating tumour soon formed, but the characteristic vibratory thrill did not appear until October of the following year. During the same winter the patient presented symptoms of softening of the brain; he became idiotic and paralyzed; and from June, 1837, until the date of his death, he had several epileptic convulsions. An attack of acute bronchitis put an end to his sufferings on the 25th of October, 1837, nearly two years and a half having elapsed since the reception of the injury.

The *post-mortem* examination showed the brain to be extensively softened, with thrombi in each lateral sinus. The internal jugular vein was found to contain the somewhat flattened ball, just behind the angle of the jaw. It was adherent to the sides of the vessel, and was retained in its position by tissues of new formation. The coats of the vein below the ball were perfectly normal in size and structure. Above, or between the missile and the base of the skull, the vein had become so much thickened as to resemble an artery, and it here communicated with the internal carotid artery, which was expanded into a sac as large as a pigeon's egg, extending from the point of communication with the vein to the carotid foramen. This pouch contained clots of old and new formation, and below it, the artery was of its natural shape and dimensions.[1]

TREATMENT OF WOUNDS OF THE INTERNAL JUGULAR VEIN.—The object of the treatment of wounds of the internal jugular vein being to restrain hemorrhage and to prevent the introduction of air, it will be found that the only measures upon which reliance can be placed are ligation and compression. *Deep inspirations*, as advised by Dupuytren as a means of arresting venous hemorrhage, are entirely out of the question, on account of the danger of air being at the same time drawn into the vessel; and even were this not the case, the measure is inapplicable, from the fact of operations being conducted under the influence of anæsthetic agents.

Styptics.—The ancients placed great reliance on incarnative or styptic remedies, combined with compression, and of these, twelve centuries ago, Paulus Ægineta writes:—

> "The most excellent of all the incarnative medicines which we know, is that used with safety for hemorrhages from the meninges of the brain, and which may be used in wounds of the neck, even for those of the jugular veins, for it will restrain a bleeding from them without a ligature. It contains of the fattest frankincense, p. j; and of aloes, when applied to soft bodies, p. ss; but when too hard, an equal quantity, and instead of the frankincense manna is to be substituted. These are to be mixed with the white of an egg until they become of the consistence of honey, when it is to be applied upon the soft down of a hare to the vessel and the whole wound; and a bandage is to be put on externally, the first four or five turns of which we are to make upon the bleeding vessel, and from thence extend to the root of it."[2]

In the first half of the last century Wiseman and Turner saturated their compresses with a styptic composed of astringent powders rubbed up with the white of an egg and vinegar. Richter, towards the close of the last century, dispensed with styptics, and advised pressure for small wounds of the internal jugular. "This is accomplished by means of graduated compresses, underneath which a small piece of sponge is placed, retained by a roller. Should the latter prove troublesome, digital compression may be substituted, and be continued for one or two days."[3]

Styptics, in conjunction with compression, may not only be dispensed with, but their employment is useless. The solution of the sesquichloride of iron, which is most commonly employed, is to be scrupulously avoided, as it has an escharotic action on the coats of the vessel, and it is very liable to excite suppurative inflammation. It will moreover produce a very extensive coagulum, which may become disintegrated, and thus lead to purulent infection.

Acupressure is inapplicable.

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[1] Encyclographie des Sciences Médicales, vol. ii., 4th ser., p. 578. 1840.

[2] The Seven Books of Paulus Ægineta, translated by Francis Adams, vol. ii. p. 128. Sydenham Society. London, 1846.

[3] Aufangsgründe der Wundarzneykunst, vol. iv. p. 173. Göttingen, 1797.

I. COMPRESSION.—Direct compression is the means usually advised by surgical writers to arrest bleeding from this vein. Mr. Pirogoff states that it has succeeded with him in every case, the number of which he does not, however, record;[1] but its adoption does not appear to have been so general as that of the ligature. Direct compression may be made by the fingers, or by plugging, in both of which it is said to be immediate, or by compresses placed over the closed wound, when it is mediate. The latter plan is to be preferred, and will answer an excellent purpose for small wounds.

Digital compression is valuable as a temporary means, in the event of the vein being opened during the performance of an operation. The finger is at once to be applied to the bleeding orifice, and retained until some time after the completion of the operation, to favour the formation of a coagulum; should the vein be completely divided, both extremities will require pressure, the cardiac end first, to prevent the entrance of air, and then the distal end to stop bleeding. As a permanent measure, the finger has been successfully resorted to in two cases—IV. V. In the former forty-eight hours sufficed to complete the cure; in the latter, seventy-two hours, but on account of its great inconveniences, permanent digital compression is not to be recommended.

Plugging was adopted in six of the successful and in both of the fatal cases; in four cases sponge, and in four charpie and lint, were the materials employed. The objections to charpie are that after its meshes have become saturated with blood, some of that fluid will escape from the external wound; and that it is liable, by the movements of the neck, as in deglutition, to be rolled into a smooth mass or ball, and become detached from the bleeding point. Sponge will, therefore, prove the very best material for tamponing. A small piece is to be retained in contact with the orifice until it adheres, when the cavity is to be filled with the same material, the external wound is to be lightly approximated by adhesive strips, and over the whole a compress is to be applied. In general, however, the latter will not be required at all, as the first piece of sponge will adhere so closely that further pressure may be dispensed with. The sponge is to be removed at the expiration of sixty hours, or three days, as was done in the case of Professor Langenbeck, at which time we may expect the wound of the vein to have become closed, or blocked up by coagulum.

Mediate compression is the most unobjectionable of all the modes of compression. The edges of the external wound having been approximated by a few points of the interrupted suture, successive layers of old linen are to be piled upon it and retained by a roller, or, better still, by adhesive strips. If the opening in the vein be small and does not gap, a moderate degree of pressure only must be exercised, in order to afford a light support to the walls of the vessel, and avoid obliteration of its cavity.

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[1] Grundzüge der Allgemeinen Kriegschirurgie, p 555. Leipzig, 1864.

The subjoined fourteen cases, all that I have been able to collect, are instances of cures by the three modes of compression:—

Ambrose Paré has narrated three cases of punctured wounds of the jugular vein, in which the lesion must have been small, as he distinctly states that large wounds are mortal from hemorrhage. He does not, however, mention which jugular was involved, except in the second case—"les rameaux de la veine et artere jugulaire"—which certainly points to the internal jugular, particularly as the recurrent laryngeal nerve was wounded. From the direction of the wounds in the first and third cases, the anterior or internal jugular was punctured, probably the latter, as the bleeding was very copious. The cases are somewhat abbreviated, but literally translated, and are well worth reproduction. To use Paré's own language, "Or en cest endroit je veux bien reciter ces trois histoires, à fin qu'elles servent d'instruction signalée pour le jeune Chirurgien, si telles playes luy tombent entre ses mains."

CASE I.—On the 1st of May, 1574, Francis Brege, a pastry-cook, was wounded in the throat by a sword, which cut a part of the tracheal artery, and one of the jugular veins, from which flowed a great quantity of blood and a whistling from the said tracheal artery. The wound was stitched, and astringent remedies applied, and shortly after the air which escaped from the wound intruded itself between the areolar tissue and muscular spaces, not only of the throat, but also of the whole body (like a sheep which has been inflated to skin it) preventing speech. The face was so swollen that there was no appearance of nose nor eyes. A consultation was held; M. Bugo thought the patient could not recover; but Master John, the younger, did not wish to leave him without doing something, and being a bold operator, made several deep incisions, by which the blood and air were evacuated. Finally the pastry-cook recovered his speech, and some time afterwards was completely cured by the grace of God. He is still living, and pursuing his occupation with the Duke of Guise.

CASE II.—A nobleman, twenty-five years of age, received a sword wound of the throat, near the tracheal artery, which cut the branches of the jugular vein and artery, followed by a very large flow of blood, which was stanched after great trouble. Moreover, one of the vocal nerves was cut: likewise the nerves which arise from the vertebræ of the neck and are distributed to the arm, on which account the arm was motionless and paralyzed. Moreover, speech was greatly impaired, and the neck became a little twisted, so that he could not turn it as formerly. He was taken to the house of Master Pierre Petotot, Master Barber-Surgeon, with whom I consulted. I greatly doubted his recovery, and for this reason I sent for MM. Cointeret and Pietre, men well versed in surgery, and we reported to the courts that the wound was mortal. I continued of the same opinion, and God cured him. The arm remained powerless and the speech impaired.

CASE III.—In the year 1550, a man was wounded by a sword thrust in the throat, which cut one of the jugular veins and the tracheal artery. There was a profuse loss of blood, and he could not articulate until the wound was stitched and dressed. On account of the very large amount of blood lost, my prognosis was early death. However, I can assure you that he escaped, a result which I believe is to be more attributed to the grace of God than to mortal means and medicines.[1]

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[1] Œuvres completes d'Ambrose Paré. Par J. F. Malgaigne, vol. ii. p. 91-93. Paris, 1840.

There can be no doubt that these cases come properly under the head of cures by compression, for Paré remarks: "Et si la playe est avec incision des veines jugulaires et arteres carotides, l'effusion de sang serra arrestée, comme nous avons descrit au chapitre du flux de sang." On referring to that chapter[1] it will be seen that Paré advises the application of styptics and compression, and if these fail, they are to be removed, and pressure with the finger on the orifice of the vessel is to be substituted until a clot has formed.

CASE IV.—"Compression indeed of itself, without any restringent at all, has stopped the most violent of these fluxes, at least for a time; a remarkable instance of which we have given us in the case of his excellency William Prince of Orange, who, in his hurt by the Spanish boy, as my Lord Bacon relates, where the internal jugular was opened, could find no way to stop the flow of blood, till the orifice of the wound was hard compressed by men's thumbs, succeeding, for their ease, one after the other, for the space of forty-eight hours, when it was hereby stanched; though Heurnius delivers the same (I suppose, bursting out again), to be suppressed, after all others tried unsuccessfully, by means of a tent armed with a digestive, and wrapt round in colcothar, or the powder of burnt vitriol."[2]

CASE V.—"Chalmetée reports a case in which the internal jugular vein had been wounded, and the person was cured in three days by digital compression."[3]

CASE VI.—Wiseman narrates the case of a gentleman who had the internal jugular pierced by a rapier. The wound was small, but it bled with a full stream. "A servant stopped it with his fingers, whilst I made dressings ready of our common astringent powders, with the white of an egg and a little acetum, spread upon a pledget of lint, and a composition of the same, with compress and such bandage as it would bear. The hemorrhage recurred several times, but the cure was complete on the twentieth day.[4]

CASE VII.—"Professor Hamilton, of Geneva College, New York, who was unfortunate enough to cut the internal jugular vein in an operation upon the neck, thrust a sponge into the wound, and allowed it to remain until suppuration removed it. The frightful hemorrhage was thus stayed, and the patient recovered"[5]

CASE VIII.—Professor Henry Miller met with a case of division of the internal jugular vein in an attempt at suicide. The loss of blood was most profuse, but as it had ceased from syncope, Dr. Rogers, who first saw the woman, merely stitched the wound of the neck, and applied compresses over the divided vessel. On the eleventh day secondary venous hemorrhage occurred with the estimated loss of one gallon of blood; and there was a considerable cavity over the vessels, filled with blood, partly fluid and partly coagulated. Compresses were again trusted to. On the sixteenth day there was an alarming repetition of the hemorrhage, but this time from the carotid artery, on which one ligature was applied below the ulcerated point of the vessel. The wound healed rapidly; there was no return of the bleeding, and the patient made a good recovery.[6]

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[1] Œuvres completes d'Ambrose Paré. Par J. F. Malgaigne, vol. i. p. 440.

[2] The Art of Surgery. By Daniel Turner, M. D. 6th ed., vol. i. p. 346. London, 1741.

[3] Enchiridion de Chirurgie, ch. 19; and Jobert, Traité de Chirurgie d'Armée, 1863, p. 428.

[4] Eight Chirurgical Treatises. 5th ed., vol. ii. p. 66. London, 1719.

[5] Cooper's Surg. Dict. Reese's Am. ed., Supplement. p. 166. New York, 1842.

[6] Western Med. and Phys. Journ., vol. i. p. 425, Nov. 1827.

Case IX.—M. Roux, in an operation upon the neck, opened the internal jugular. The wound was plugged and the patient recovered.[1]

Case X.—Professor Langenbeck wounded the internal jugular in the removal of a cyst of the neck, to which the sheath of the vessels was intimately connected. The wound was filled with charpie, and its edges were drawn together by adhesive strips. A compress was placed upon the wound, and retained in position by a towel. On the third day the parts were dressed and the compress and charpie dispensed with: and on the thirteenth day the wound had cicatrized. A portion of the vein four lines long and two lines in breadth had been sliced away.[2]

Case XI.—M. Bégin reports the removal of a cancerous tumour of the neck, during which the internal jugular vein was wounded and air was aspired. The orifice was immediately compressed by the finger and the operation finished. At its completion methodical compression, in the usual manner, was substituted, and the patient recovered without a bad symptom.[3]

Case XII.—M. Velpeau reports a case similar to that of M. Bégin in which the hemorrhage was successfully repressed by compression deep in the wound. Air had gained admittance into the opened internal jugular.[4]

Case XIII.—Mr. John Adams saw a servant girl, thirteen years of age, who had fallen through a skylight, June 9th, 1862. When brought to the hospital, she was exsanguine and almost pulseless, and presented a deep, irregular wound in the right submaxillary space, from which, however, there was no bleeding. On removing the clot, a gush of blood ensued. Mr. Adams at once introduced his finger, upon which Mr. Curling enlarged the wound by dividing the skin upwards and downwards, in order that the bleeding vessel might be secured. This could not be reached, and the cavity was plugged with pieces of sponge. The edges of the wound were brought together by adhesive strips, and a compress was retained by means of a roller. On the 30th the wound had nearly united, and there had been no intermediate hemorrhage.[5]

Case XIV.—"In wounds of this vein—internal jugular—it might be possible even to save the patient by plugging and compression, as was the case with an ancestor of the distinguished Mirabeau."[6]

The following cases in which compression was employed were fatal, the first from secondary hemorrhage, the second from apoplexy:—

Case I.—The late Mr. Gray has recorded the following facts: "A man was admitted into St. George's Hospital on July 14th, 1847, having cut his throat with a penknife, which was followed by profuse hemorrhage. On the left side of the neck, a little below the cricoid cartilage, was a wound about an inch and a half in length, extending transversely across the space between the sterno-mastoid and trachea, partially dividing the muscles in this situation, and passing for some distance under the skin towards the clavicle. Dark blood was still welling from the wound, which was plugged with sponges, and pressure with the fingers applied. At 1 P. M. the wound was dilated upwards and downwards, no bleeding vessel was discovered, and it was evident that the bleeding proceeded from the lower end of the wound. About half a pint of blood was lost before the sponges were reapplied. The wound gradually suppurated, and the last sponge had been removed when a deep granulating cavity was seen, with a slough in the direction of the sheath of the vessels. On July 22d, at 5 P. M., the hemorrhage suddenly recurred to an alarming extent, and the patient died in the evening. On inspection of the body, a slough, completely destroying the front wall of the internal jugular vein for three inches of its extent, was found. The sloughing extended from about an inch above the junction of the vein with the subclavian, upwards; the posterior half of the vessel alone remaining. The common carotid artery had also been wounded at its anterior part; the opening was small, and was blocked up by lymph and coagulum, which was intimately adherent to the edges of the wound."[1]

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[1] Malgaigne's Traité d'Anat. Chir. et de Chir. Expérimentale, vol. i. p. 346. Paris, 1859.

[2] Archiv für Klin. Chir., vol. i. p. 25. Berlin, 1860.

[3] Presse Médicale, July 22d, 1837, p. 463.

[4] Mémoires de l'Académie Royale de Médecine, vol. xvi. p. 358. Paris, 1852.

[5] Medical Times and Gazette, Aug. 9th, 1862, p. 125.

[6] Professor Pancoast, A Treatise on Operative Surgery, p. 47. Phila., 1852.

Case II.—Dr. Heineken has recorded the following unique case: "A soldier in the artillery was stabbed between the condyle of the lower jaw and the mastoid process, just below the lobe of the ear on the left side. The knife with which the wound was inflicted was about two inches and a half in length, about an inch in breadth, with a slight curve at its point; and it had been plunged up to the handle. Profuse bleeding ensued, which one of his comrades stopped by pressing with his finger upon the wound, after a large quantity of blood had been lost; and he was removed to the Portuguese hospital. Upon examination the temporal artery was found to be wounded, and with considerable difficulty was secured by ligatures. Upon the removal of pressure the hemorrhage returned almost as violently as ever, and in a constant full stream of the size of a goose-quill. As the man was greatly exhausted by the large quantity of blood lost, the first object was to suppress the hemorrhage as speedily as possible; and with this intent the wound was filled with pieces of sponge, and compresses were applied over them. In two hours from the suppression of the hemorrhage he became comatose, with paralysis of the right arm and leg, and a full pulse. Twelve ounces of blood were taken from the arm, an active cathartic given, and in the evening, as the symptoms remained the same, other twelve ounces were abstracted. On the following day the same plan of treatment was persevered in, and about every eighth hour more or less blood was withdrawn, but without giving any decided relief. On the seventh day he expired apoplectic. Upon examination a wound more than half an inch in length was found in the internal jugular vein immediately below the base of the skull, and, with the exception of the temporal artery before mentioned, no other vessel, nerve, or part of consequence was injured. There was no opportunity of opening the skull."[2]

Objections to Compression.—The treatment of wounds of the internal jugular vein by compression is open to the same accidents as the application of the ligature, and is also attended with some inconveniences and positive drawbacks, which demand consideration.

First. Unless the wound be small, the amount of pressure brought to bear upon the bleeding orifice—the soft tissues of the neck intervening—will be so great as not only to be painful, but it will also interfere with deglutition, and more or less with respiration.

Secondly. When the compression is immediate, and made directly upon the opening, the pain inflicted will be the greater, and a suppurating cavity is produced, by which primary union of the soft parts is defeated. Moreover the sponge, charpie, or lint, will, if not removed before suppurative action is set up, confine the discharges, which will soon become offensive, and may give rise to diffused phlebitis.

Secondary hemorrhage has occurred in three instances. One of these—

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[1] A System of Surgery, edited by T. Holmes, vol. ii. p. 276. London, 1861.

[2] Edinburgh Med. and Surg. Journ., vol. xxx. p. 103. 1828.

that of Mr. Gray—was fatal, the bleeding having recurred on the eighth day, from destruction of the anterior wall of the vessel to the extent of three inches. In this case, on enlarging the wound, no bleeding vessel was discovered; but it was evident that the blood proceeded from below, and the wound was plugged with sponges. In Case VI. of the cures by compression, bleeding recurred on several occasions; and in Case VIII., the amount of blood lost on the eleventh day was enormous.

In Case X., Table I.,[1] it is scarcely probable that Professor Langenbeck could have omitted compression; but in this, as well as in the other fatal cases, the plan of treatment is not recorded.

Apoplexy.—In one case—that of Dr. Heineken—apoplexy was the cause of death. The situation of the wounded vein was such as to preclude the possibility of applying a ligature, and the wound was plugged with pieces of sponge, over which compresses were applied. Although the man was greatly exhausted by the loss of blood, *he became comatose, with paralysis of the right arm and leg,* in two hours after the suppression of the hemorrhage from the *left* internal jugular. Repeated bleedings failed to give decided relief, and he expired apoplectic on the seventh day.

Although there was no post-mortem examination of the head in the above case, there is strong reason to believe that the cerebral disturbance was due to the means employed to arrest the hemorrhage. That the sudden cutting off of the return of one-half of the venous blood from the brain and its membranes can be followed by such an event, admits of no discussion, more especially if there be also an impediment to the venous circulation of the opposite side. When the internal jugular is fully compressed, more blood enters the cranium by the arteries than can be returned by the veins. The result of this is that the brain will suffer from engorgement of the venous system, and the effects of this congestion show themselves in one or more of the varied symptoms of an apoplectic tendency, as loss of consciousness, disordered vision, ringing of the ears, giddiness, and drowsiness. These signs are usually evanescent, disappearing as soon as the blood has found new channels of return. The free collateral circulation, of which more will be said under the head of ligation of the vein, and the presence of the cephalo-spinal fluid have, in the great majority of instances, prevented even these symptoms.

The fear of producing apoplexy, by totally occluding the vessel, prevented Professor Wattman, of Vienna, from throwing a ligature around the whole circumference of the vein, and the lateral ligature, which he practised in its stead, was followed by paralysis and loss of sensation in the upper and lower extremities of the opposite side, for several days. In his case of cure of wound of the internal jugular by compression, Professor Miller, of Louisville, referring to the hemorrhage, remarks: "It occurred to us that suppression might be effected, and the patient secured against all possibility of its return, by a ligature of the jugular vein. Our recollection, however, not furnishing any precedent for such an operation, and an apprehension that the brain might suffer fatal compression from the sudden interception of so considerable a stream of refluent blood, deterred us from adopting that expedient."

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[1] See January number of this Journal, p. 44.

Dr. Gurlt narrates a case of compression of one jugular vein by a tumour, attended with symptoms of congestion, as headache, dimness of vision, flashes of light, and enlargement of the subcutaneous veins.[1] As a rule, however, signs of cerebral disturbance are to be looked for in those cases only in which the obstruction to the return of blood is sudden. In the instances of Haller, Lardner, Hodgson, Warren, Smith, Horner, McClellan, Langenbeck, Simson, Ulrich, and other writers, the vein was obliterated by morbid growths, and in none of these were symptoms of cerebral congestion present.

In connection with these cases it is interesting to note that apoplexy has also resulted from the interrupted circulation of both jugulars. Sir Astley Cooper performed some experiments upon rabbits by tying both jugulars. On the seventh day one rabbit was convulsed and frequently rolled over. The voluntary powers were lost, as well as sensation to a great degree, and death took place. A clot of blood was found in the left ventricle. "Hence it follows that apoplexy will follow occasionally an obstruction to the return of blood, and this I have known to happen from enlargement of the glands of the neck of a boy."[2] Mr. John Bell also relates an example of a tumour of the neck producing a similar result.[3] Dr. Abercrombie narrates the following instances of apoplexy referable to interrupted circulation:—

> "A boy mentioned by Zitzilius had drawn his neckcloth remarkably tight, and was whipping his top, stooping and rising alternately, when, after a short time, he fell down apoplectic. The neckcloth being unloosened, and blood being drawn from the jugular vein, he speedily recovered. Kortum mentions a Swedish officer, who, to make his men look well in the face, obliged them to wear their collars very tight; the consequence was, that, in a few years, half the regiment died of apoplexy. Strangulation, when the neck is not dislocated, seems to be simply apoplexy. A man, brought after execution to Sauvages, was recovered by three bleedings, sat up and talked, his breathing and deglutition being natural. After a short time, the part of his neck where the cord had been applied began to swell, so as evidently to impede the circulation in the veins of the neck; he became drowsy, his pulse and respiration slow, without dyspnœa, and in a few hours he died apoplectic. A woman, mentioned by Wepfer, recovered after execution under the same treatment. After her recovery, she was for some time affected with vertigo, which subsided gradually."[4]

Instrumental compression, I may suggest, may be substituted for plugging and external compresses when the vessel is visible. For this purpose small spring forceps may be used to which a string is attached to facilitate its removal. In this way Mr. Porter controlled bleeding from the femoral vein in a thigh amputation, the small artery forceps of Dieffenbach having been pulled away in forty-eight hours.[1] By the use of such a contrivance for a wounded internal jugular vein, the pain will be less than after filling the wound with charpie or sponge, and the amount of suppuration will be much diminished.

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[1] Archiv für Klin. Chirur., vol. i. p. 59.

[2] Guy's Hospital Reports, vol. i. p. 471, 1836.

[3] Principles of Surgery, vol. ii. p. 556.

[4] Edinburgh Med. and Surg. Journal, Nov. 1818, p. 572.

It is to be remembered that an incomplete wound, unless very small, will furnish more blood than a wound entirely dividing the coats of the vessel, as the contraction of the fibrous elements of the vein causes the orifice to gap and assume a somewhat oval shape. The rule of practice should, therefore, always consist in following the example of the ancients, namely, complete division of the vessel so as to permit each end to retract within its sheath. By such a procedure the bleeding will be much diminished, and, in conjunction with any of the modes of compression, will favour the chances of a successful issue.

II. LIGATION.—The obliteration of the cavity of so large a vein as the internal jugular would at first sight appear to be a formidable operation, not only on account of the supposed dangers of phlebitis, but also from the effects of impairment of the cerebral circulation. The only attempts to collect these cases have been made by Professor Gibson, of this city, who narrates six examples, including his own;[2] and by the late Professor Malgaigne, who has reported sixteen cases, embracing those of Dr. Gibson.[3] It is to be regretted that M. Malgaigne has made but mere allusion to the facts which he had gathered; but they were sufficient to warrant him in concluding that ligation of the vein was not more dangerous than that of the carotid artery.

With the exceptions above mentioned, the great majority of cases of ligation of this vein seems to have escaped the attention of surgeons, so much so indeed that Mr. O'Shaughnessy, in reporting his own case, thinks it the first successful instance on record. In this, however, he is greatly mistaken, as ten instances precede him. Although to Professor Simson is due the merit of priority, it will be found that the measure was alluded to, but not carried into effect, before he reported his case in 1747. Thus, in 1563, although we have not been able to find the edition of that year, Thomas Gale writes :—

"The fourth manner of stitching is, when as a veine or arterie is cut, and we use to staie the flux of blood, especiallie when as vene jugularis

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[1] Dublin Quarterly Journal. Nov. 1863, p. 268.

[2] Institutes and Practice of Surgery, 8th edition, vol. i. p. 200. Philadelphia: Kay & Bro. 1850.

[3] Op. cit., vol. i., chapter x., pp. 341-346.

> is cut. Then we thrust ye needle through that veine or arterie and then knit the same with the threed, then drawe out the needle, and let a portion of the threed hang out so long untill it falleth awaie."[1]

Heister advises to treat small wounds of the internal jugular vein with dry lint, which is to be confined with a compress and roller; but of large wounds he says:—

> "I would advise him (the surgeon) to make a pressure upon the divided vein with his finger, and to enlarge the wound upwards and lengthways, till he can come at enough of the vessel to make a strong ligature upon it by the assistance of a crooked needle. By this means the life of the patient may be saved, though the course of the blood through the vessel be entirely cut off. I have often tried this experiment upon a dog, and he has recovered, and never suffered any apparent inconvenience from it; therefore I think it is better to put this doubtful remedy into execution than to leave the case as desperate."[2]

Fabricius ab Aquapendente inculcates the precept of Celsus in speaking of wounds of the carotid artery and internal jugular vein, when he says:—

> "Si sanguis sistere non potest, statim debet hamo apprehendere vas vulneratum et attollere, deinde partes utrinque filo ligare, et transversum totum vas præscindere."[3]

Even those authors who are opposed to the general application of the ligature to wounded veins admit that it will be required when the internal jugular is involved. Mr. Erichsen, writing of the introduction of air, advises

> "The first thing to be done is to prevent the ingress of air, by compressing the wounded vein with the finger, and, if practicable, securing it by ligature."[4]

It may be inferred from the preceding remarks that the jugular vein will require a ligature to prevent alarming and fatal hemorrhage and as an expedient against the introduction of air, both of which occurrences demand some investigation.

1. *The introduction of air* into the heart through an open jugular vein is much more to be feared than hemorrhage; and the reported cases show that it is more liable to occur when the vein has been opened near its entrance into the brachio-cephalic, as at this point, as well as throughout nearly the whole of the lower third of its extent we have the phenomenon of "venous inspiration," the blood and air being freely sucked into the

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[1] Certaine Workes of Chirurgie, newlie Compiled and Published by Thomas Gale, Maister in Chirurgerie. London, 1586. The first Book of the Enchiridion, p. 35.

[2] A General System of Surgery, 2d edition, p. 76. London, 1745.

[3] Opera Chirurgica, p. 251. 1723.

[4] Edinburgh Medical and Surgical Journal, January, 1844, p. 19. Science and Art of Surgery, p. 147. Phila. 1859.

heart at each inspiratory effort. The aspiration of air has been the invariable result of an incised wound, made by the surgeon in the removal of tumours in ten instances, and once in raising up the vein, which had been divided in a suicidal attempt, to tie it. In the latter case the air was heard to enter the vein, but there were no general symptoms referable to the accident. In the cases of Wattmann, Smith, Asmus, Mirault, Brodie, and Erichsen, as may be seen by consulting Table No. II., not only was the peculiar lapping or whizzing noise heard, but there were alarming signs of trouble of the organs within the chest, as immediate syncope, tetanic spasms, and opisthotonos. A fatal result occurred after the application of a thread in the case of M. Mirault only, death ensuing from asphyxia in a little more than three hours. Two other cases of the accident, cured by pressure, have been considered at page 310; and three examples of fatal issue at page 38, January number of this Journal. It is thus seen that the accident is by no means very frequent, or necessarily fatal. The occurrence of eleven cases in eighty-six of wounds of the internal jugular vein, treated of in this paper, gives a ratio of 12.79 per cent.; four cases, or 36.36 per cent., were fatal, while seven cases, or 63.63 per cent., recovered under suitable treatment.

Treatment.—The possibility of air finding its way into the heart through a wounded vein, should teach the surgeon to avoid the accident as much as possible, more particularly in his operative procedures about the root of the neck, where the suction force of inspiration is present. Should an opening be made in that point of the vein, without the necessary precautions having been taken, sudden death may ensue, as happened in the cases of MM. Gorré and Ulrich. The conditions most favourable to the production of the accident are the canalization of the vessel from inflammatory thickening of its walls, preventing their collapse when divided, and a patulous condition when cut through, owing to its normal attachments to the surrounding fascia. When the vein is imbedded in or is firmly attached to a tumour, the accident has usually followed the division of its pedicle; but an incomplete division with traction on the tumour, by which the orifice is kept open, is equally to be feared.

The *preventive* measures refer to the avoidance of all the causes which tend to produce the accident, and the infliction of a wound upon the vessel, so that in the removal of deep-seated tumours of the neck, in which the vein is involved, the precaution must be taken either to compress the vessel with the finger, or to cast a thread around it on the cardiac side of the tumour, before it is divided. This ligature of expedience must never be withheld, no matter what the peculiar views of the surgeon may be in regard to it. The *curative* measures have for their first object the prevention of further admission of air. The vein having been accidentally opened, or completely divided, the finger must at once be placed on the wound and a ligature applied on the cardiac extremity. In this way four of the five cases of ligation terminated successfully, the amount of air introduced into the circulation not having been sufficient to produce its purely mechanical effect of obstructing the capillaries of the lungs. In all cases in which a ligature is required on the continuity of a vein, two threads will generally be found necessary, with or without the intermediate division of the vessel, the upper one to guard against hemorrhage, the lower to prevent the accident under consideration; and the same remark will apply to those cases where the vein is simply punctured or completely divided. The other means merely refer to those measures employed for alarming syncope, and do not require discussion.

2. *Hemorrhage.*—From the large size of the internal jugular vein, the absence of valves, and from the current of blood passing from above downwards, it is naturally to be expected that a large wound, resulting in complete or almost complete division, will furnish a very large quantity of blood from the peripheral or distal end, as well as from the cardiac end during expiration. In all the cases, where this occurrence has been mentioned, it is stated as having been "very profuse," or "very copious." In the case of Professor Miller, Case VIII., p. 309, the amount was estimated to be about one gallon. In the only case that I have witnessed, occurring in the practice of Professor Gross, a large vein, probably the facial, was sliced off, so to speak, at its point of entrance into the jugular, leaving a large round opening from which a copious and very embarrassing stream of blood escaped, and which was with some difficulty arrested by the application of two ligatures, one above and the other below the opening. Hemorrhage may be the cause of death primarily or secondarily. The former occurrence was seen in but four cases, or in 4.65 per cent. of the whole number; the longest duration of life being a little more than one hour. The case of Mr. Samuel Cooper is interesting from the mode of fatal termination; the subcutaneous hemorrhage having induced suffocation by pressure on the trachea. Secondary hemorrhage was fatal in ten cases, or in 11.62 per cent. of the whole number; six times, or 6.97 per cent., when no ligature was employed, and four times, or 4.65 per cent. when it was adopted, the bleeding having come on in a period varying from four to fifteen days. Taking the whole number of cases then at 86, and the whole number of deaths from hemorrhage at 14, we shall find that hemorrhage has been the cause of death after wound of the internal jugular vein in 16.27 per cent. of all cases. There were in all 37 deaths, which give the ratio of 37.83 per cent. of all the fatal cases referable to hemorrhage.

It is interesting to note that in three cases of wound of the vein the bleeding was reflux, requiring a ligature on the cardiac side only, as the upper end did not emit blood. In other cases where but one ligature was used, the upper end, and not the lower, required deligation. Indeed cases have been reported of the removal of a portion of an internal jugular vein with a tumour, in which there was no hemorrhage from either end, the cavity of the vessel having become obliterated. A case of this nature occurred to Dr. Danzel, of Hamburg, who removed a portion of the vein with an encephaloid tumour of the neck, without any hemorrhage, the vessel having been closed by the pressure of the tumour.[1]

Treatment.—For the arrest of hemorrhage the ligature has been employed much oftener than compression, and with the best results. The mode of applying the thread has already been referred to; but it is to be remembered that reflux bleeding may occur from the cardiac end, so that it is advisable to use two ligatures in every case, the more so if the wound be closed before the effects of chloroform have passed off, as in such a case it may happen that the divided vein will not bleed until the patient has completely recovered, as was witnessed by Mr. O'Shaughnessy. The precaution must also be taken, in throwing the thread around the lower end, to prevent the introduction of air, which happened to Mr. Erichsen when the vein was raised to tie it.

Temporary ligation may be employed by those surgeons who fear the effects of a permanent thread, to dispense with digital compression when the vein has been wounded. In such an event the bleeding is very embarrassing to the operator in his deep dissections, and as the fingers of an assistant would only be in his way, a thread may be applied with a slip knot, so that it can be removed on the completion of the operation. Or, instead of this, very delicate spring forceps, or the modified serres-fines of M. Vidal, may be used, and will be found to answer a good purpose.

Permanent ligation is the measure which above all others recommends itself in the treatment of wounds of this vein, as it does away with the pain and other inconveniences of compression, as well as acts as a barrier to the extension of local inflammation from unhealthy suppurating wounds, as I have pointed out in the January number of this Journal. The ligature may be applied in two ways, namely, merely to include the wounded part, when it is known as *lateral*, or to include the whole circumference of the vessel, when it may be termed *direct.*

Lateral ligation was first practised by Mr. Travers, in 1816, for a small wound of the femoral vein, and first applied to the internal jugular by Dr. Wattmann, in 1823. It does not obliterate the vessel, as was shown by Mr. Guthrie in his case of suicidal wound. The cut was picked up with a tenaculum, and a delicate thread thrown around it. On the ninth day the man died of exhaustion consequent upon secondary hemorrhage from the common carotid artery, when the vein "was found pervious and without a mark indicating where the ligature had been applied." Professor Pancoast, of this city, advises when a vein is punctured to pass a couple of fine pins through the edges and across the orifice, and to embrace the opening in a delicate silk ligature, and then withdraw the pins;[2] a procedure manifestly inapplicable to a vein of such magnitude as the internal jugular, as the hemorrhage will prove too embarrassing, and will not admit of the time required to carry the procedure into effect. It will be better to use the common spring forceps to nip up the opening, as the instrument at the same time possesses the advantage of controlling the bleeding. This mode of applying the thread would seem to recommend itself from the fact of its not interfering with the cavity of the vessel, whereas the direct ligature obliterates it.

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[1] Archiv für Klinische Chirurgie, vol. vii., 3d Part, p. 887. Berlin, 1866.

[2] A Treatise on Operative Surgery, p. 47, 3d Edition. Philadelphia, 1852.

Lateral ligation is, however, dangerous, and should be excluded from practice.—By referring to the tables of ligation of the internal jugular vein, it will be seen that Cases 22, 23 and 24, in which it was employed, were fatal from secondary hemorrhage towards the sixteenth day; and it is also very probable that it was used in Case 21. Were these cases excluded from the tables, there would be no deaths to record from secondary hemorrhage. It has also proved to be the cause of death in several instances of tied femoral veins, and must, therefore, be discarded from practice; although the successful cases of Guthrie, Bégin, and Wattmann show that it is by no means to be regarded as an entirely unsafe procedure.

Direct or complete ligation was first practised by Professor Simson, of St. Andrews, Scotland, and is the method which should always be employed. Nothing need be said of the mode of applying the thread, as it is merely the ordinary procedure, excepting that the forceps are to be preferred to the tenaculum for picking up the vein, not only to arrest hemorrhage, but to guard against the introduction of air. A delicate silk thread should be used, and one end clipped off close to the knot.

3. *Ligation of the Corresponding Artery.*—In the very interesting paper already alluded to, Professor Langenbeck advises ligation of the corresponding artery for wounds of the internal jugular, axillary, external iliac and femoral veins, when compression has failed to arrest the hemorrhage. He does not favour tying the internal jugular vein, as it entails, he thinks, the dangers of thrombosis and pyæmia, and would prefer giving a trial to ligation of the carotid artery, paying no attention at all to the wound of the vein.[1] Professor Langenbeck considers this a sure means; but by what process of reasoning, with all due respect for the author, I have been unable to discover. Indeed, he seems to have but little confidence in his own statement, since, if he had, he would have trusted to it in the case of the little girl, given at page 69 of his paper, instead of applying two threads to the jugular vein. The suggestion of Professor Langenbeck is not a new one, as Dr. Heineken had alluded to it in connection with the case detailed at page 311, in which the internal jugular had been opened to the extent of half an inch, just below the base of the skull. He remarks: "The only chance of preventing the accident from proving fatal

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[1] Archiv für Klinische Chirurgie, Band i. p. 52 *et seq.*

consisted in permanently reducing the supply of blood to the brain. This might have been attempted by tying the carotid on the same side, and, had evidence of pressure on the brain still continued, by putting a ligature around the other carotid also."[1]

The ligation of one carotid artery does not prevent the access of blood to the brain, as the ligation of the femoral artery would cut off the supply of blood from the lower extremity. The intra-cranial circulation is peculiar; there is a free communication between all the vessels, a wise provision, which, if it did not exist, would leave us no remedy for wounds of the vessels of the neck. Ligation of both carotids might answer the purpose, as suggested by Dr. Heineken, as the blood carried into the brain would have to traverse the vertebral arteries, which being contained in bony canals would not enlarge. The supply of blood through these channels being small, time might be given for the wound of the vein to heal; but no one, I presume will be found bold or foolish enough to carry the suggestion into effect when a ligature on the vein or compression will accomplish the object. In the last case of the second table, in which a cyst was removed from the neck, the carotid artery was laid bare to a short extent, and gave me an opportunity of compressing it firmly against the spine. I need hardly say that it had no effect whatever on the bleeding jugular. It may be added, however, that the procedure advised by Professor Langenbeck has been attended with success in wounds of the veins of the extremities, and that he has supported his opinion by the narration of a case of wounded femoral vein, the coats of which were so brittle as not to hold a thread. The hemorrhage was rebellious, but was stopped by ligating the femoral artery. I have collected several analogous cases, which will be reported at a future date.

Effects of Ligatures on Veins.—There is a very decided difference of opinion in regard to the action of a ligature upon the coats of a vein. Mr. Hodgson says: "When a vein is tied with a thin ligature, the internal surface of the vessel is lacerated;[2] and Mr. Travers demonstrated that "a ligature does not divide the internal tunic of a vein either in man or animals."[3] This non-division of the lining membrane had been pointed out by Bichat;[4] but Mr. Travers also showed that it was thrown into longitudinal folds, and that "it appears as if the outer or cellular coat only was divided;" an opinion that has been generally adopted by the profession. From some experiments upon the larger human veins, which may be repeated and verified by any one, I have been led to different conclusions. When a delicate, strong, and well-waxed silk thread is drawn as tightly as possible around a vein, its coats become plicated or thrown into longitudinal folds or plaits. Upon slitting open the vessel, these folds are seen to be well marked, but without any division of the tunics; and upon holding the vessel between the eye and light, a decided transverse furrow or indentation, corresponding with the site of the ligature, is observable, which would, at first sight, seem to be due to injury of one or more of its coats. The external and internal tunics can be made to glide over the furrow by the finger, showing that some lesion exists in the middle coat, and a mere superficial examination will lead to the opinion that it has been completely divided. A more minute inspection and dissection, however, clearly disclose that the inner layer, consisting of circular elastic fibres, only has been cut, or rather separated, leaving the longitudinal fibres unharmed and closely connected with the uninjured external tunic. With the exception then of the impression made upon a portion of the middle layer, none of the coats of the vein suffer division. The external tunic seems to be as strong as that of an artery in resisting the ligature; the middle coat differs from that of an artery in having longitudinal as well as circular fibres, the former being composed of white fibrous tissue with elastic fibres, the latter of elastic fibres arranged in the same manner as those of an artery, with an admixture of a large quantity of unstriped muscular fibres. The inner tunic is more dense and tough, but not nearly so lacerable as that of an artery, and can be stripped off the middle coat much more readily and to a greater extent. I have, indeed, peeled off one unbroken surface of upwards of two inches from the inferior cava, and on applying a ligature to it, it suffered no division. It is thus seen that the anatomical structure of a vein materially differs from that of an artery, and that, when tied, none of its coats are divided, as is the case with the latter vessel. It is, moreover, easy to conceive that the walls of the vein being thrown into folds, offer a mechanical obstacle to their own division by a tightly drawn thread.

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[1] Edinburgh Med. and Surg. Journ., vol. xxx. p. 104, 1828.

[2] On Diseases of Arteries and Veins, p. 555.

[3] Essay cit., p. 201.

[4] General Anatomy. Translated by Dr. Hayward. Vol. i. p. 402. Boston, 1822.

From the experiments of Mr. Travers[1] upon the jugular vein of the horse, it is found that up to the sixth day the vein on each side of the ligature is thrown into longitudinal folds, the lower portion being empty, collapsed, and uninflamed, the upper extremity being filled with a firm coagulum of several inches in extent. The lining membrane shows not only no blush, but no signs of adhesive inflammation or adhesion of the contiguous folds, while the cellular sheath of the vein is thickened by a deposit of lymph in the vicinity of the ligature. The appearances are the same when the vessel is divided between two ligatures, the division permitting the ends to retract to the extent of an inch. At seven days the effusion of lymph into the cellular tissue around the ligature is increased, and the thread is surrounded by adhesive matter external to the vessel. At nine days ulceration of the venous walls begins, and the separation of the ligature is accomplished in a period of from fifteen to twenty-five days. In a young and healthy horse the thread came away on the twenty-fifth day.

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[1] See Surgical Essays, London, 1818, Part I. p. 273, *et seq.*

> "The ulcerated ends of the vein formed a crescentic sweep, and were separated to the extent of an inch, and fastened by adhesion to the cellular sheath, which was much extended and thickened by a subjacent deposition of lymph, so as to form a smooth, solid bed between the divided ends of the vein. The internal membrane of the superior portion of the vein had a thin, ragged edge where it had been severed by ulceration. The lower edge was smooth and blended in with the bed of the wound. The extremities had undergone no contraction but that produced by the adhesion of the severed extremity to the sheath. The portion of the vein next the heart was empty. The upper was filled by a dark lamellated coagulum of blood, adhering very strictly to the internal tunic which was discoloured by it. On carefully separating the outer lamella which coated the interior of the vein, I could not discover any thickening of the proper coats of the vein, nor any appearance of inflammatory action within its canal, nor was any such appearance indicated in the lower portion of the vein." pp. 274–5.

From the above changes in the coats of the vein, Mr. Travers infers that the internal coat is little susceptible of inflammatory action, and that the healing process, as well as the dropping off of the ligature by ulcerative action, is conducted without any appreciable sign of inflammation of the lining membrane. Indeed, he says "the veins do not adhere after being tied; nor do their wounds under ordinary circumstances cicatrize immediately, nor do the cut ends contract and inflame." These opinions are opposed to those of Bichat, Mr. Hunter, Mr. Hodgson, Dr. Mackenzie, and other observers, and the phenomena described by Mr. Travers are undoubtedly due, if not to inflammation, to an irritation closely allied to that condition.

Finally, to sum up the changes produced by the application of a ligature, it is found that none of the tunics are divided; that the blood in the interior of the vessel becomes consolidated on the distal side of the thread; that adhesive inflammation sets in, followed by effusion of plastic material in the coats of the vessel, between the coagulum and the lining membrane, and in the surrounding tissues; that the vessel on the proximal side is closed without the formation of a coagulum; and that the clot undergoes various changes, becomes organized, and with the corresponding walls of the vessel is ultimately converted into a firm fibro-ligamentous cord.

Collateral Circulation.—As some bad consequences, namely—capillary venous congestion, serous effusion, apoplexy, softening of the brain, paralysis, and œdema of the soft parts—have been referred to the sudden interruption of the return of venous blood from the brain and its membranes to the heart, by the application of a ligature to the internal jugular vein, it will be necessary to glance at the collateral circulation. Some of the cases have been attended by signs of venous congestion, but there is an anatomical arrangement by which the brain escapes danger. All the sinuses of the dura mater communicate with each other at the torcular Herophili, from which the lateral sinuses pass to the posterior lacerated foramina, to become the internal jugular veins, so that if one be obstructed the current of blood is directed to that of the opposite side. The anterior and external jugular veins are supplemental trunks and have free communications with the former set. The veins of the walls of the cranium have a direct anastomatic communication with the sinuses of the dura mater, and the rachidian system of veins also freely inosculates with the cerebral veins, so that they afford great aid to the circulation. Of the latter plexus, indeed, M. Cruveilhier remarks: "If all the jugular veins were obliterated, the venous circulation of the head would still continue, and would be carried on by the spinal veins."[1]

It is thus obvious that when one internal jugular vein is tied, the blood will find its way to the heart by the internal jugular of the opposite side, and by the external jugular of the same side. The latter vein I have seen, in several cases of tumours of the neck compressing the deep jugular, very much enlarged and tortuous, and that condition is, therefore, to be considered as the best diagnostic sign of the internal jugular being involved by morbid growths. From these considerations, and from the fact that many cases of obstruction of one jugular vein by tumours have been unattended by signs of cerebral congestion, that state is not to be anticipated whenever a ligature is deemed necessary; although, as will be seen hereafter, the procedure gave rise to symptoms denotive of the occurrence of venous congestion in one instance.

In addition to the above indirect anastomoses, a beautiful example of direct communication between the ends of a tied jugular vein of a horse, has been observed by MM. Renault and Bouley. The animal was killed thirty days after ligation of both internal jugulars. Two collateral veins arising above had carried on the circulation; but whereas, before ligation, they had carried blood to the jugular, their function was now changed, since they received the blood from its upper end, and carried it to a venous network developed entirely around the tied vein at the site of the thread. This venous rete was composed of vessels of the size of small quills, freely communicating with each other, their united diameters being fully equal to that of the obliterated vein itself. Two other main trunks left this network, and emptied into the lower end of the jugular below its point of obliteration.[2]

From the above description this case would, I think, resemble the figure of a tied carotid artery, delineated by Dr. Ebel, in which precisely the same condition existed.[1] A similar anastomosis between the ends of the femoral vein of a dog, which was killed on the thirty-seventh day after ligation of that vessel and the femoral artery, is described by Dr. Jones. "The vein was obliterated to a greater extent than the artery, and the superior and inferior portions communicated freely by branches which went from one to the other."[2]

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[1] Anatomy of the Human Body. Amer. edition, p. 611. New York, 1844.

[2] Recueil de Médecine Vétérinaire, vol. xvii. p. 547; and Malgaigne, vol. i. p. 340.

The following are brief abstracts of all the cases of ligation of the internal jugular vein which I have been able to collect. Twenty-eight refer to the extirpation of tumours; five to suicidal wounds; one to gunshot wound; two to stabs; two to ligation of the carotid artery; and in three cases the cause is not mentioned. For more easy consultation, as well as to point out the sources from which they have been gathered, the cases are separated into two tables; one relating to the vein alone, the other to the vein and the carotid artery; an arrangement which has been deemed necessary for the proper appreciation of some of the assumed dangers of ligation. It is to be remarked that there is one case on record, which has not been used in this paper as it has no practical value in a statistical inquiry, of *ligation of the vein by mistake*. Mr. Crisp reports it as follows: "A case has recently come to my knowledge where a surgeon tied the vein instead of the artery, and the mistake was not discovered until after death. The patient was a child, and the operation was required for hemorrhage, resulting from an abscess in the neck."[3] The result of such treatment would necessarily be an increased instead of diminished flow of blood.

CASE I.—Dr. Thomas Simson, Professor of Medicine in the University of St. Andrews, Scotland, records the first instance of the application of a ligature to the internal jugular vein, which was required during the extirpation of an ulcerated tumour of the right side of the neck, in which the vessel was imbedded. Professor Simson says: "In dissecting out this tumour, I laid the carotid artery bare for about two inches, and plainly saw its pulsation; as it sends out no branches about this part of the neck, I wrought with greater resolution. From the upper part of the tumour a cartilaginous process went to the larynx, to which it was strongly attached. In cutting this away, there was a strong jet of blood from an artery, which soon stopped, after the application of spirit of wine to it, so that I went on with the dissection of the tumour from the vein downwards. After laying the vein bare a considerable way, I found it confounded at the lower part with the substance of the tumour; and therefore, putting a ligature around the vein, I tied it, and then cut away the remaining part of the tumour below, except a small part, in which I thought the vein was involved, expecting the ligature would make this fall off; but seeing no appearance of such a separation, after eight days, I cut it through immediately below the ligature, and found vein and all quite solid, of a cartilaginous firmness. After this hard substance was all taken away, the large cavity where the tumour had been lodged filled up very fast, so that the wound was cicatrized in six weeks."

CASE II.—Mr. Simmons, of Manchester, England, "has also published a case in which he tied the internal jugular vein. In this case a large tumour on the left side of the neck extended from the outer margin of the sterno-cleido-mastoideus muscle nearly to the shoulder. The tumour was extirpated. 'The divided arteries bled freely, but the blood rushed in a torrent from the internal jugular vein, which had been divided in the operation.' The vein was tied with three ligatures, which came away in due time without hemorrhage, and the parts healed in about two months. In this case it was remarked that no morbid affection of the head was the consequence of the obliteration of the internal jugular vein."

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[1] De Natura Medicatrice sicubi Arteriæ Vulneratæ et Ligatæ Fuerunt. Giess. 1826.

[2] Treatise on Hemorrhage, p. 150. London, 1805.

[3] Op. cit., p. 217.

CASE III.—Dr. Richter, treating of wounds of the neck, in his "Aufansgründe der Wundarzneykunst," states that the internal jugular vein has been ligated with a happy result.

CASE IV.—Professor Wattmann, of Vienna, applied a lateral ligature to the right internal jugular, in removing a tumour of the neck. Although air had entered the vein, the patient gradually recovered, his left upper and lower extremities having been paralyzed for several days. The thread came away on the twelfth day.

CASE V.—Professor Stevens, of New York, embraced the internal jugular vein with two threads, above and below the entrance of a large divided vein, during the extirpation of an adenoid tumour of the neck. The patient recovered, and the ligatures came away on the fourteenth day.

CASE VI.—The late Professor Mott removed a tuberculated sarcomatous tumour of the neck, the hemorrhage requiring the ligation of the internal and external jugular veins and the external carotid artery. A small portion of the growth was included in the ligature around the internal jugular, and the woman recovered.

CASE VII.—Professor Gibson, of this city, tied the internal jugular with two threads, and divided the vessel between them, in the extirpation of an adenoid tumour of the neck. Previous to the operation the common carotid artery was ligated as a precaution against hemorrhage, and during the operation the descendens noni nerve was cut across, as it was in the way. The threads were pulled away from the vein on the thirty-third day, and the ligature came away from the artery three days subsequently. The boy made a good recovery.

CASE VIII.—Dr. J. G. Morgan, of New York, applied two ligatures to the internal jugular, which had been divided in about three-fifths of its circumference in an attempt at suicide. The bleeding was frightful, but the man's life was saved, the threads coming away on the eighth and tenth days.

CASE IX.—The late Professor J. C. Warren, of Boston, during the removal of a tumour, tied the internal jugular with two threads, a portion of the vein being left in the growth. The common carotid artery was also ligated, and the patient recovered.

CASE X.—M. Mirault, of Angers, removed a tumour from the neck. Air was aspired, and a ligature was applied on the cardiac side to prevent its further ingress. Death ensued in three hours. For farther particulars see Case III. of fatal cases from introduction of air, in the January number of this Journal.

CASE XI.—Dr. Asmus opened the internal jugular vein in an operation for the removal of a tumour of the neck, and air was aspired, followed by immediate syncope with convulsions and violent opisthotonos. The patient recovered from the primary effects of the introduction of air in twelve minutes, under the use of stimulants, pressure having been kept up with the finger applied to the orifice of the wounded vessel. The upper end of the vein was tied, and the man made a good recovery.

CASE XII.—Dr. A. B. Mott, of New York, included the internal jugular in two threads, a piece of the vessel having been cut out in a suicidal attempt.

When first seen, the young man was pulseless from loss of blood, and had to be resuscitated by artificial respiration. He however recovered, the ligatures coming away on the twelfth and thirteenth days.

CASE XIII.—M. Maisonneuve, of Paris, tied the distal end of the internal jugular vein, which had been divided in the removal of an enormous tumour of the neck. The man recovered.

CASE XIV.—M. Widmer, on the authority of M. Velpeau, has successfully ligated the internal jugular.

CASE XV.—M. Gély, on the authority of M. Malgaigne, met with recovery after ligature of the internal jugular.

CASES XVI., XVII.—M. Sédillot has in two instances ligated the internal jugular, leaving a portion of the vein in glands of a suspicious nature. Both patients recovered.

CASE XVIII.—M. Bégin, on the authority of M. Legouest, had a successful issue in a case of lateral ligature of the internal jugular.

CASE XIX.—Professor Barovero, of Turin, accidentally included the *left* internal jugular vein in the ligature of the common carotid for the suppression of hemorrhage from an encephaloid tumour situated behind the right angle of the jaw. Up to the tenth day there was giddiness, spectral delirium, and palsy of the left side of the mouth and the left hand. On the sixtieth day, symptoms of gastric fever set in, which speedily assumed the tertian form, and "acquired a pernicious character in the course of a few days, with loss of sensation, sopor, and death on the sixty-ninth day after the operation." The brain and its vessels were found in a state similar to that of chronic inflammation; and the anterior part of the *right* lobe was covered by a fluid similar to a puriform exhalation.

CASE XX.—Mr. Guthrie tied the internal jugular laterally in an attempt at suicide. The cut was picked up with a tenaculum, and a fine thread applied. The common carotid artery was nicked transversely, but the incision did not extend beyond the middle coat. On the eighth day hemorrhage took place from the artery, which was cut down upon and ligated, but the patient died on the following morning from exhaustion. "The internal jugular was found pervious, and without a mark indicating where the ligature had been applied."

CASE XXI.—M. Giraud has recorded a case in which a French military surgeon, at Toulouse, tied the trunks of the internal jugular and common carotid for a gunshot wound. The man had no unfavourable symptom as far as the sixth day; but it is not stated whether he recovered.

CASE XXII.—M. Labat, on the authority of M. Larrey, in his "*Mémoire sur l'Adénite Cervicale*," ligated the internal jugular and common carotid, and divided the pneumogastric nerve in removing a very large scirrhous tumour of the neck, and the patient recovered in six weeks. The external jugular was also tied.

CASE XXIII.—Sir Benjamin Brodie applied two ligatures to the internal jugular in the removal of a tumour. Air had gained admission into the vein, but the patient recovered.

CASE XXIV.—Mr. Erichsen tied the internal jugular above and below a wound made in a suicidal attempt. The man made a good recovery, notwithstanding air was heard to enter the vein when it was raised to tie it.

CASE XXV.—Professor Pancoast, of this city, applied two ligatures to the internal jugular in extirpating the parotid gland. The internal carotid artery was also tied, and the man recovered.

CASE XXVI.—Professor N. R. Smith, of Baltimore, tied the internal jugular on its cardiac side, near its termination, on account of appalling recurrent hemorrhage in the removal of a medullary sarcoma of the neck. The vessel was involved in the disease; its coats soft and brittle, and, near its junction with the subclavian vein, had been largely rent by the slight traction made upon it. Air had been aspired. Death from exhaustion on tenth day. "It is manifest, therefore, that he could not have died from phlebitis, which by some is supposed almost necessarily to arise from the application of ligatures to veins of such very large size, and in a diseased condition."

CASE XXVII.—M. Sanson, on the authority of M. Malgaigne, reports a fatal case from hemorrhage upon separation of the ligature of the internal jugular.

CASES XXVIII., XXIX., XXX.—M. Roux, on the authority of M. Nélaton, tried lateral ligature of the internal jugular in three cases. The threads came away towards the sixteenth day, and all perished from secondary hemorrhage.

CASE XXXI.—Dr. Neudörfer, of the Austrian army, in a conversation with the author of this paper, early in August, 1866, remarked that he had applied two ligatures to the internal jugular during the removal of a tumour of the neck, and that death ensued from causes unconnected with the procedure. In fact, the post-mortem inspection showed that the vein had undergone no change whatever.

CASE XXXII.—Professor Schuh, on the authority of Dr. Neudörfer, tied the internal jugular with two threads in extirpating a tumour of the neck. The patient died, but the vein was healthy.

CASE XXXIII.—The late Professor Mott, in the removal of a very extensive glandular tumour of the neck, tied both ends of the internal jugular. About three inches of the vein were imbedded in and taken away with the mass. The middle third of the sterno-cleido-mastoid muscle was also removed, and the boy, five years of age, made a rapid recovery.

CASE XXXIV.—Professor Langenbeck, of Berlin, in a case of extirpation of the tumour of the neck, applied two ligatures to the internal jugular, a portion of which was exsected with the mass. The girl died on the twenty-fifth day, having had all the symptoms of pyæmia. A post-mortem examination was not permitted.

CASE XXXV.—Professor Langenbeck wounded the internal jugular during the removal of an epithelial cancer, and placed a thread on the cardiac end only, there being no bleeding from the distal extremity. The common carotid artery being intimately connected with the morbid growth was included in two ligatures and divided. At the time of the operation the man was suffering from bronchitis, from which he died on the twelfth day.

A post-mortem examination showed the vein completely healed as if by the first intention, without the slightest trace of redness, thickening of its walls, or the formation of a clot. The vessels of the dura mater and surface of the brain were slightly injected, and there was a little serous effusion at the base of the skull. The lungs were slightly œdematous, and at the apex of the right lung there were old tubercular deposits. The bronchial tubes were filled with mucus, and there were some pleural adhesions.

CASE XXXVI.—Professor Langenbeck reports a case similar to the above, in which the internal jugular and common carotid were tied. The man was sixty-five years of age, and the puncture of the vein was very small. As the bleeding from the upper end ceased of itself when the cardiac side was ligated, nothing was done to it. Towards the completion of the operation, there was significant hyperæsthesia, so that the patient complained greatly on stitching the wound. His pulse was weak, but the temperature on each side of the head was the same. He gradually sank and died at the expiration of forty-eight hours. An accurate examination of the ligatured vessels showed nothing abnormal. A nerve had been included, thus accounting for the increased sensibility. The lungs were œdematous, and the bronchial tubes contained a slight quantity of mucus. The brain and other organs were normal.

CASE XXXVII.—Professor Gross, in August, 1866, removed an encysted tumour of the neck. During the dissection, a large vein emptying into the internal jugular was divided so close to the latter that two ligatures were thrown around it above and below the opening on account of the very profuse hemorrhage. The man made a good recovery, and had not a single untoward symptom. The threads came away on the tenth day.

CASE XXXVIII.—Mr. O'Shaughnessy removed a large tumour of the right side of the neck together with a portion of the internal jugular vein, which was firmly adherent to it. Two ligatures were applied. The man recovered, and the vein did not bleed until the effects of chloroform had passed away.

CASE XXXIX.—MM. Marcé and Mounier applied two ligatures to the internal jugular vein which had been nearly divided in a suicidal attempt. One ligature came away on the sixteenth day, and the other was remaining in the wound, which had completely cicatrized on the thirty-third day. Recovery.

CASE XL.—Dr. John Watson, of New York, tied with separate threads the left internal jugular vein and primitive carotid artery of a woman who had been stabbed in the neck and who had lost much blood, but without arresting the arterial hemorrhage. Death ensued from softening of the brain at the expiration of fifty-seven hours, when the ligatures were seen to be in position, and the hemorrhage was found to have proceeded from the vertebral artery, which was nearly divided about half an inch above its origin.

CASE XLI.—Dr. Zeis, of Dresden, tied the *left* common carotid for nævus in an infant *fifteen months* old. On opening the sheath and exposing the internal jugular vein there was a gush of venous blood, which was stopped by creasote water. "The vein which had been tied swelled so much as to excite fear of its bursting, and was therefore tied again higher up, after which the artery was tied with a silk thread." The tumour immediately became swollen and shrivelled up; after seventy-two days the wound had healed. On the fourth day the ligatures came away from the vein, followed in twenty-four hours by venous bleeding, which recurred six times in the course of the next twenty-four hours, but each time was arrested by creasote water. "About a week before the complete healing of the wound, the child was attacked suddenly with convulsions and *hemiplegia of the right side*; these symptoms continued with increasing activity, and on the forty-ninth day after the attack of convulsions, the child died." No examination was allowed.

TABLE II.—*Cases of Ligation of the Jugular Vein alone.*

Case.	Operator.	Authority.	Mode of ligation.	Cause.	Result and cause of death.	Observations.
1	Simson, 1747	Med. Essays and Observations, vol. 5. Part I. 3d ed., p. 335. Edinburgh, 1747	One thread distal side	Removal of tumour	Recovery	First recorded case. Ligature cut away on the eighth day.
2	Simmons, 1791	A Treatise on the Diseases of Arteries and Veins. By Joseph Hodgson. p. 535. London, 1815	Three ligatures	Removal of tumour	Recovery	
3	Richter, 1797	Anfangsgründe der Wundarzneykunst. Band 4, p. 173. Göttingen, 1797	....	Wound of neck	Recovery	
4	Wattmann, 1823	Cormack's Monthly Journal of Med. Science, 1844, p. 783	Lateral	Removal of tumour	Recovery	Longitudinal opening to the extent of two and a half lines. *Air was aspired*, followed by immediate syncope; recovery gradual; paralysis of left extremities for several days. Ligature came away on the twelfth day.
5	Stevens, 1830	Cooper's Surgical Dictionary, Am. ed. Supplement, p. 165. New York, 1842	Two threads	Removal of tumour	Recovery	The threads came away on the fourteenth day.
6	Smith, 1834	Baltimore Med. and Surg. Journal, July, 1834	One thread cardiac side	Removal of tumour	Death from exhaustion	No signs of phlebitis. *Air had entered the heart*, and the patient fell back inanimate. Sucking noise heard.
7	Morgan, 1836	Am. Journ. Med. Sciences, vol. xviii. p. 330. 1836	Two threads	Cut-throat	Recovery	The vein was more than one-half divided, and the loss of blood was profuse. The upper ligature came off on the eighth day, *the lower on the tenth day.*
8	Mirault, 1837	Compendium de Chirurgie Pratique, vol. i. p 80. Paris, 1840	One thread cardiac side	Removal of tumour	Death in 3 hours from introduction of air	Ligature was applied to prevent *further aspiration of air.* Whizzing noise heard and tetanic spasms. Recovery from effects of air in eight minutes; but death from asphyxia.
9	Asmus, 1842	American Journ. Med. Sci., Jan. 1843, p. 220.	Two threads	Removal of tumour	Recovery	*Air was aspired.* Syncope, convulsions, violent opisthotonos. Recovery from effects of air not complete until fourteen hours had elapsed.
10	Erichsen, 1844	Edinburgh Med. and Surg. Journal, p. 19. January, 1844	Two threads	Cut-throat	Recovery	Air entered the divided vein when it was raised to tie it.
11	O'Shaughnessy, 1848	London Lancet, June 23, 1849, p. 661	Two threads	Removal of tumour	Recovery	Portion of vein excised with tumour. *No bleeding until effects of chloroform were passing away.*
12	V. Mott, 1848	Transactions of New York Academy of Medicine, vol. i. p. 90. 1857	Two threads	Removal of tumour	Recovery	About three inches of the vein were imbedded in and removed with the tumour.
13	Brodie, 1849	London Medical Gazette, vol. ix. n. s. p. 266. 1849	Two threads	Removal of tumour	Recovery	*Air aspired.* Sudden syncope, and patient thought to be dead.
14	Marcé & Mounier, 1854	Revue Méd.-Chir. de Paris, vol. xvi. 1854, p. 215	Two threads	Cut-throat	Recovery	Vein nearly divided. One thread came away on the 16th day; the other remaining on 33d day, when wound nearly healed.
15	A. B. Mott, 1855	Am. Med. Monthly, Nov. 1856, p. 326	Two threads	Cut-throat	Recovery	A portion of the vein had been cut out, and the man was nearly dead when seen. The threads came away on the twelfth and thirteenth days.
16	Maisonneuve, 1855	Gaz. Médicale de Paris, p. 402. 1855	One thread distal side	Removal of tumour	Recovery	

TABLE II.—*Cases of Ligation of the Jugular Vein alone.* (Continued.)

Case.	Operator.	Authority.	Mode of ligation.	Cause.	Result and cause of death.	Observations.
17–18	Sédillot, 1855	Traité de Médecine Opératoire, p. 193. Paris, 1855	Two threads	Removal of tumours	Recovery	Portion of veins excised with the tumours.
19	Widmer, 1856	Velpeau's Operative Surgery, 4th Am. ed. Vol. I. p. 809. New York, 1856	....	....	Recovery	
20	Gély, 1859	Traité d'Anatomie Chirurgicale et de Chirurgie Expérimentale. Par J. F. Malgaigne. Vol. I. p. 342. Paris, 1859	....	....	Recovery	
21	Sanson, 1859	Malgaigne, ut supra, p. 342	One thread (lateral?)	....	Death from hemorrhage	
22–23–24	Roux, 1859	Malgaigne, ut supra, p. 343	Lateral	Removal of tumours	Death from secondary hemorrhage	Ligatures came away towards the sixteenth day.
25	Langenbeck, 1859	Archiv für Klinische Chirurgie, Band I. p. 69. Berlin, 1860	Two threads	Removal of tumour	Death from pyæmia on 25th day	Portion of vein removed with tumour. Threads came away by light traction on the twenty-third day. *No post-mortem examination*; but symptoms of purulent infection during life. Some œdema of the face.
26	Bégin, 1863	Legouest. Traité de Chirurgie d'Armée, p. 429. Paris, 1863	Lateral	Removal of tumour	Recovery	
27	Neudörfer, 1866	Verbal communication to the author	Two threads	Removal of tumour	Death from exhaustion	Vein had undergone no change whatever, so that the ligatures had nothing to do with the fatal issue.
28	Schuh, 1866	Dr. Neudörfer	Two threads	Removal of tumour	Death from exhaustion	Cause of death not connected with ligatures.
29	S. D. Gross, 1866	Unpublished case witnessed by author	Two threads	Removal of tumour	Recovery	Threads came away on tenth day. Not a single bad symptom.

TABLE III.—*Cases of Ligation of the Internal Jugular Vein and Carotid Artery.*

Case.	Operator.	Authority.	Mode of ligation.	Causes.	Artery ligated.	Result.	Observations and post-mortem appearances.
1	V. Mott, 1832	Am. Journ. Med. Sci., vol. xii. p. 121. 1833	One ligature	Removal of tumour	Ext. carotid	Recovery	Ext. jugular also tied. No cerebral disturbance.
2	Barovero, 1835	Edinburgh Med. and Surg. Journ., vol. xliii. p. 483. 1835	One ligature including artery	Hemorrhage from encephaloid tumour of neck	Com. carotid	Death on 69th day from gastritis and pernicious fever	Immediate signs of cerebral trouble; giddiness, spectral delirium, and palsy of left side of mouth and left hand. Continued for ten days. On 60th day symptoms of gastric fever; became pernicious, with loss of sensation; sopor, and death in 9 days. "Upon inspection the brain and its vessels were found in a state similar to that of chronic inflammation; and the anterior part of the *right* lobe was covered by a fluid similar to a puriform exhalation." *Left* vessels tied.
3	J. Pancoast,	Verbal communication to the author	Two ligatures	Extirpation of parotid gland	Internal carotid	Recovery	No cerebral disturbance.

Case.	Operator.	Authority.	Mode of ligation.	Causes.	Artery ligated.	Result.	Observations and post-mortem appearances.
4	Guthrie, 1830	Diseases and Injuries of the Arteries, p. 328. London, 1830	Lateral ligature	Cut-throat	Com. carotid on 8th day	Death from exhaustion the result of arterial hemorrhage	The artery had been nearly divided at time of suicidal attempt. "*The internal jugular was found pervious, and without a mark indicating where the ligature had been applied.*"
5	Labat, 1834	Mémoires de l'Académie Royale de Médecine, vol. xvi. p. 360. Paris, 1852	One ligature	Removal of tumour	Com. carotid	Recovery	Pneumogastric nerve divided. Ext. jugular also tied. Cure complete in six weeks, with some nervous and hemorrhagic accidents.
6	A French surgeon mentioned by Giraud, 1850	Gibson's Surgery, 8th ed., vol. i. p. 200. Phila., 1850	One ligature including artery	Gunshot wound	Com. carotid	Uncertain; but did well up to 6th dy. No fur. hist.	
7	Langenbeck, 1859	Archiv für Klinische Chirurgie. Band I. p. 73. Berlin, 1860	One ligature cardiac side	Removal of tumour	Com. carotid 2 ligatures & division bet. them	Death from bronchitis on 12th day	Intellectual faculties unimpaired, and no signs indicative of obstruction to cerebral circulation. Vein completely healed without trace of clot, redness, or thickening of its walls. Old pleural adhesions. Bronchial tubes filled with mucus; lungs œdematous, and at apex of right lung old tubercular deposits. Vessels of dura mater and surface of brain slightly injected: a little serum effused at base of skull. Other organs normal. Firm clot in the carotid.
8	Langenbeck, 1859	Ibid., p. 77	One ligature cardiac side	Removal of tumour	Com. carotid 2 ligatures & division bet. them	Death in 48 hours. Man gradually sank	Temperature of both sides of head and neck the same. Intellect and special senses unimpaired. An accurate examination of the ligated vessels showed nothing to account for the fatal result. There was marked œdema of the lungs, and the bronchial tubes contained some mucus. The brain and other organs were *normal*.
9	Gibson, 1832	Am. Journ. Med. Sci., vol. xiii. p. 305. 1833	Two ligatures and division bet. them	Removal of tumour	Common carotid. One thread, as a precaution against hem.	Recovery	Ligatures pulled from vein on the 33d day. Ligature came away from carotid five days later. The descendens noni nerve was in the way and was divided. No cerebral disturbance.
10	J. C. Warren, 1837	Surgical Observations on Tumours. Boston, 1837. p. 177	Two ligatures	Removal of tumour	Com. carotid one thread	Recovery	A portion of the vein left in the tumour. The vessels of right side had been ligated. Following morning some delirium. Temperature of right side of head lower than the opposite. Left pulse very feeble. Great difficulty in moving left arm and leg, but not exactly paralysis.
11	Watson, 1853	New York Journal of Medicine, July, 1857. p. 40	One thread	Stab in the neck	Left common carotid one thread	Death from acute softening of the brain	Operation on evening of 5th of October. In 48 hours somnolency, bordering on coma, followed in 4 hours by hemiplegia of right side, and strabismus. Death at 1 o'clock, morning of 8th. Ligatures in position on artery and vein. The hemorrhage which had defied the carotid deligation was found to have proceeded from the vertebral artery which was nearly divided about one half an inch above its origin. "The substance of the brain appeared, in places, to *have* been somewhat softened. The pleura of both sides was found inflamed, and contained a considerable amount of sero-purulent fluid."
12	Zeis, 1847	Chelius's System of Surgery, vol. ii. p. 608. Phila., 1847	Two threads	Ligation of carotid for vascular nævus	Left common carotid, one thread	Death on 114th day from *softening of brain*	Ligatures came away on 4th day, and on following night considerable venous bleeding, recurring 6 times in next 24 hours, but arrested by creasote water. Wound had healed in 72 days, but about a week previously child was *attacked with convulsions and hemiplegia of right side. These symptoms* continued with increasing debility, and on the 44th day after the attack of convulsions the child died. No post-mortem examination was allowed.

Simultaneous Ligation of the Carotid Artery and Internal Jugular Vein.—There are some points in connection with the third table which demand separate examination, as it has happened in twelve cases of removal of tumours and wounds of the neck, that not only the vein, but also the common carotid artery, or one of its branches, has required the ligature. It has been supposed that, when such an event occurs, the dangers to be apprehended from the disturbance to the cerebral circulation are so much enhanced as greatly to invalidate the chances of success, and that gangrene, as evinced by softening of the brain, would ensue. This precept has been inculcated as strenuously as that of mortification of the lower extremity following obliteration of its main arterial and venous trunks. Professor Velpeau, in his remarks on the operation of tying the carotid, says:—

> "If, unfortunately, the internal jugular vein should happen to be opened, I do not know whether it would be better to tie it, or to stop the hemorrhage by tents. But to say nothing of phlebitis, which, in this case—ligation—is the most formidable consequence to apprehend, who would not hesitate in obliterating so large a vein, at the same time with the principal artery of the head?" (*Op. cit.*, vol. i. p. 869.)

Professor Gross uses the following language in regard to the treatment of carotid aneurism by compression:—

> "It cannot be brought into play here, the parts being intolerant of the requisite manipulation, to say nothing of the obstruction which it would occasion to the return of blood in the internal jugular vein, which, being dammed up in the brain and sinuses of the dura mater, might speedily induce apoplexy, or other serious cerebral symptoms, endangering the patient's life." (*Op. cit.*, 4th ed., vol. i. p. 717.)

When the carotid artery alone is tied, it is obvious that there is less blood sent to the head than in the normal condition, and that, as a consequence, there will be capillary cerebral anæmia until the anastomotic circulation is fully established. This disturbance of the cerebral circulation is often followed by immediate or remote symptoms of functional or organic lesions of the brain, and of the latter, atrophic softening from deficient arterial supply, or acute or chronic inflammatory softening are the most common pathological states.

Brain trouble, according to Mr. Erichsen (*op. cit.*, p. 633), as indicated by immediate or remote symptoms, has been present in about one-fifth of the cases, one-half of which were fatal. Dr. Ehrmann's statistics show that 42 instances of cerebral disturbance of some kind ensued from ligation of one carotid in 184 cases, the percentage being about 22.

If the internal jugular vein of one side be tied, or the return of blood be interfered with by compression, congestion of the brain may ensue. The case of Dr. Heineken goes to show that the blocking up of the blood may produce death by coma; but the ligature has entailed no such result. Indeed, in the twenty-nine cases in which the vein alone was tied, that of Dr. Wattmann alone presented any symptoms referable to some lesion of the brain.

The vein of the *right* side was tied *laterally*, and after the patient had revived from the effects of the introduction of air, there was hemiplegia of the *left* upper and lower extremities. "After twenty-four hours, pain was felt in the paralyzed limbs, which seemed to be a forerunner of spasmodic contractions. These lasted for three days, diminishing in strength daily, and after they had disappeared, the sensation and voluntary movements of both limbs were as perfect as formerly." It is useless to try to explain these disorders by the ligature, as the cavity of the vein was not obliterated, so that there was no impediment to the return of venous blood; but the paralysis and hyperæsthesia must be referred to some lesion of the brain itself. It is thus seen that neither apoplexy, nor softening of the brain, nor even functional disturbance can be ascribed to tying one vein.

The preceding remarks have been called forth as introductory to a statement made by Professor Langenbeck, at page 51 of his paper, to the effect that "when both artery and vein are tied, not only does gangrene not follow, but there is less disturbance to the capillary circulation than when the vein or artery alone is tied. In two cases of ligation of the common carotid and internal jugular vein, we have observed no phenomena indicative of obstruction to the cerebral circulation. The intellectual faculties were unimpaired, and there was no weakness or paralysis of the limbs."

The above statement is true of Professor Langenbeck's own cases; but from an examination of those contained in the third table it is obvious that a more extended record does not confirm his positive assertions. Of the twelve cases two are to be excluded: that of M. Labat, who dismisses it himself with the remark that the case recovered with some nervous and hemorrhagic accidents; and that reported by M. Giraud, as no result is given. Ten cases thus remain for investigation. Of these, six, namely, the two of Langenbeck, those of Mott, Pancoast, Gibson, and Guthrie, were unattended either by immediate or remote signs of functional or organic disturbance of the brain; whilst that of Dr. Watson terminated fatally from acute cerebral softening, as seen upon post-mortem inspection; that of Dr. Zeis, at a very remote period, from chronic disorder, and that of Dr. Barovero from chronic inflammation. In the case of Professor Warren, in which the vessels of the *right* side were tied, there was some functional disturbance, as shown by "great difficulty in moving the *left* arm and leg;" but the condition was not exactly that of paralysis. In the case of Dr. Zeis, the *left* vessels were tied. On the 65th day the infant was attacked with convulsions and *hemiplegia of the right side*. These symptoms continued with increasing debility until the 49th day after the attack of convulsions, when the child died; but no examination was allowed. Dr. Watson tied the *left* vessels in his case. In 48 hours there was somnolency bordering on coma, followed in four hours by *hemiplegia of the right side* and strabismus, in which condition the man died 57 hours after the operation. Dr. Barovero tied the vessels of the *left* side with one thread, and the operation was succeeded by immediate signs of cerebral trouble, as giddiness, spectral delirium and palsy *of the left side* of the mouth and of the left hand. These phenomena continued for ten days. On the 60th day there were symptoms of gastric fever, which soon became pernicious, with loss of sensation, sopor, and death in nine days. The dissection showed evidences of chronic inflammation. *From these data it thus appears that signs of cerebral disturbance followed ligation of the common carotid artery and internal jugular vein in 40 per cent. of the cases, of which 75 per cent. proved fatal; death having ensued in one case from acute softening, in one from chronic softening, and in one from chronic inflammation. The statement of Professor Langenbeck, which was based upon a too limited experience, that "gangrene is not to be feared," must, therefore, be rejected.*

The question naturally arises, How are these phenomena to be accounted for? I am myself at a loss to explain them. It has been seen, on the one hand, that these symptoms are not produced when the vein alone is tied, and, on the other, that they frequently follow ligation of the artery. I am disposed to refer them solely to the sudden interruption of the arterial circulation; and I do not deny the statement of Professor Langenbeck that "an equilibrium is maintained between the arteries and veins until the collateral circulation has been established;" I only differ from him in regard to the occurrence of softening of the brain. Indeed, in the case of Dr. Heineken, the plugging may have obstructed the internal carotid artery, and thus have given rise to the fatal coma. Professor Langenbeck's deductions seem *a priori* to be reasonable; and it is very certain that gangrene does not always follow simultaneous ligation of the principal artery and vein of an extremity. I have collected many cases of this procedure, and, as I have stated in the preceding part of this essay, the operation was very common in the latter part of the last century, and was even practised by Mr. Hunter himself, without the production of mortification. That gangrene is not only not an inevitable result, but is rarely to be looked for, is well shown by the cases of Professor Grillo, of Naples, who included the femoral artery and vein in the same ligature in fifteen cases of aneurism of the ham or lower part of the thigh. These were all successful; while in fourteen other cases, in which the artery was isolated and alone tied, there were two deaths from secondary hemorrhage.[1]

It would appear that in two of the cases of Table III. both vessels were included in the same thread, a procedure which should not be imitated, as death might result from secondary hemorrhage. In such a case, the vein being interposed between the ligature and the artery, the thread would act mediately upon the coats of the latter vessel, and not produce the desired effects.

Remarks on the Ligature.—The merit of having first applied a thread to the internal jugular vein is due to Dr. Simson, of Scotland, the procedure having been employed at least forty times since the publication of his case.

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[1] Gazette Médicale de Paris, p. 539. 1834.

The *effects* of the thread, as seen upon the human subject, are mentioned in the cases of Mr. Guthrie and Dr. Langenbeck, which illustrate the healing process after the application of each form of ligature. In the case of the former a lateral ligature was used, and on the ninth day the internal jugular vein was found pervious, without any mark indicating where it had been applied. In that of the latter, in which the vessel was completely surrounded by the thread, the inspection on the twelfth day showed the "vein completely healed, without trace of clot, redness, or thickening of its walls."

The *date of separation* is noted in eleven cases, and refers to seventeen ligatures. The shortest time was four days, the longest twenty-three days; the average thirteen days. One thread was cut away on the eighth day; two were pulled away on the thirty-third day; and one was remaining at the same date.

Substance and Number.—As metallic ligatures are not mentioned, it is assumed that silk or flax was employed in all the cases. In regard to the number, it is found to have varied from one to three. Of the thirty-seven cases in which the mode of application is mentioned, seventeen were single, nineteen double, and one treble. Of the single threads, six were lateral; two were applied to the upper end, and four to the lower end; in two cases the same thread included the common carotid artery; and the site of the remainder is uncertain. Of the double ligatures only three were peculiar: in one instance there was intermediate division of the vessel, and in two cases the threads were applied above and below the orifice of a divided vein emptying into the internal jugular.

Secondary hemorrhage occurred in five cases, affording a percentage of 12.2, of which 80 per cent. were fatal from the use of the lateral ligature.

The *mortality* after ligation of the internal jugular vein, as based upon forty cases in which the result is known, is but 12.5 per cent.; or, if the fatal case of pyæmia be rejected as due to the ligature, the mortality is reduced to 10 per cent.

It is to be remarked that in the cases of Sédillot, Mott, O'Shaughnessy, Warren, and Langenbeck, portions of the vein were excised with morbid growths; in one instance to the extent of about three inches.

Bad Effects from Ligation.—The evil consequences which have been assumed as resulting from obstruction of the internal jugular are entirely unfounded. An inspection of the twenty-nine cases of Table No. II. shows that capillary venous congestion, serous effusion, gangrene, and apoplexy have not resulted in a single instance. In the case of Dr. Wattmann, in which a lateral ligature was applied, and which consequently did not interfere with the return of blood from the brain, there was hemiplegia of the opposite side for several days; a phenomenon which I have already endeavoured to explain by some coexisting lesion of the brain. In only one instance of the entire forty-one cases, that of Langenbeck, Case 25, Table No. II., was there any œdema. This was slight, and was confined to the corresponding side of the face;[1] and I am, therefore, inclined to believe that those authors who fear œdematous swelling on the distal side of the ligature, have applied the experiments of Lower on the dog to the human subject. Nearly two hundred years ago, Lower tied both jugulars of a dog, an operation from which death resulted in forty-eight hours. The areolar tissue of the head and neck was enormously distended with serous effusion.[2] According to Morgagni,[3] the experiments of Galen, Emettus, L'Amur, and Novesius showed no disturbance of the cerebral functions after ligation of the internal and external jugular veins; and no mention whatever is made of œdema. It may, therefore, be concluded that when one jugular vein is obstructed by the ligature, the free collateral circulation always prevents cerebral disorders, and that the occurrence of œdema is the exception to the general rule.

General Results of all Cases of Injuries and Operations in which the Internal Jugular Vein was wounded.—One case is excluded from the last table, as its termination is unknown; so that there are 85 instances, with 37 deaths, or a mortality of 43.52 per cent. The causes of death were in the following proportions:—

	Cases.	Per cent. of all cases.	Per cent. of all deaths.
Secondary hemorrhage . .	10	11.76	27.02
Pyæmia	6	7.05	16.21
Primary hemorrhage	4	4.70	10.81
Introduction of air . . .	4	4.70	10.81
Exhaustion	6	7.05	16.21
Cerebral disorders . . .	6	7.05	16.21
Epilepsy	1	1.17	2.70

General Results of No Treatment.—20 cases; all fatal, or a mortality of 100 per cent.:—

	Cases.	Per cent.
Introduction of air	4	20
Primary hemorrhage	4	20
Pyæmia	5	25
Secondary hemorrhage	5	25
Epilepsy	1	5
Softening of the brain	1	5

General Results where Compression was employed.—16 cases; 2 deaths, or a mortality of 12.5 per cent.:—

	Cases.	Per cent.
Secondary hemorrhage	1	6.25
Apoplexy	1	6.25

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[1] See Langenbeck's paper, p. 50.

[2] Tractatus de Corde, etc., p. 123 et seq. 1669.

[3] Cooke's Morgagni, vol. ii. p. 567 et seq. Boston, 1824.

General Results of Cases in which the Ligature was employed.—40 cases; 15 deaths, or a mortality of 37.5 per cent.:—

	Cases.	Per cent.
Exhaustion	6	15
Secondary hemorrhage	4	10
Chronic softening of brain	2	5
Acute softening of brain	1	2.5
Bronchitis	1	2.5
Pyæmia	1	2.5

In arriving at the preceding general results, it is distinctly to be borne in mind that the injury of the vein was in but few cases uncomplicated by other injuries. Of the 85 cases, the vessel was injured 37 times in the removal of tumours; 16 times by stabs; 12 times by gunshot injuries; 8 times by suicidal wounds; 3 times by accidental wounds; 7 times by other wounds, the nature of which is uncertain; and twice in ligating the common carotid artery. The true results of wounds of the internal jugular vein may, then, thus be stated, premising that the ligature was the cause of a fatal result in but four cases: Mortality of cases not subjected to treatment, or in which the treatment is not stated, 100 per cent.; mortality of cases subjected to compression, 12.5 per cent.; mortality of cases in which the deaths are referable to the ligature, 10 per cent.

General Conclusions.—From all the data contained in this paper, I have arrived at the following conclusions in regard to wounds of the internal jugular vein:—

First. That incised and punctured wounds of the internal jugular vein are to be classed among the most fatal of accidents; and, if subjected to no treatment, are invariably mortal from primary hemorrhage, the introduction of air, pyæmia, or secondary hemorrhage.

Secondly. That gunshot wounds of the vein alone are always fatal from primary or secondary hemorrhage, or pyæmia.

Thirdly. That when the carotid artery is opened at the same time, either as a result of gunshot, incised, or punctured wound, the case may, under favourable circumstances, recover, but with the formation of an arterio-venous aneurism.

Fourthly. That compression is followed by a fatal result as often as ligation; is more painful and inconvenient, and is to be resorted to in those cases only in which a thread is inapplicable from the high situation of the wound, or when the vein is merely punctured, and the measure can be applied mediately.

Fifthly. That ligation is more convenient, produces neither pain nor a suppurating cavity; and, that the fears of exciting diffused phlebitis are utterly groundless, as there is not a single example showing that such an inflammation has followed its employment. The ligature is, moreover, called for to guard against the introduction of air and prevent its further ingress, as well as to prevent the occurrence of diffused phlebitis.

Sixthly. That the lateral ligature is to be avoided, as it has been the cause of all the fatal results from secondary hemorrhage; and that both ends of the wounded or divided vessel are to be tied, since reflux hemorrhage is not an infrequent occurrence.

Seventhly. That ligature of the common carotid artery will not restrain the flow of blood from a wounded internal jugular vein, and is, therefore, to be rejected as a hemostatic measure.

Eighthly. That not only has the danger of pyæmia after ligation of the vein been greatly exaggerated, but that all the dangers are also hypothetical, as neither apoplexy, softening of the brain, nor other cerebral disorders have ensued from its employment, the collateral circulation being amply sufficient to prevent those accidents.

Ninthly. That the cause of death after ligation is not to be looked for in the production of pyæmia, as the fatal issue has, in every instance, been due to secondary hemorrhage, coming on about the time of the separation of the thread.

Appendix.—The value of these general conclusions is enhanced, and their truth verified, by several additional cases that I have collected since this paper went to press. The first two demonstrate the safety and efficacy of the ligature: that of Mr. Fleming, which has generally been overlooked, is interesting from the fact of its being the first recorded example of ligation of the common carotid artery in its continuity, after rupture of the artery itself. Its similarity to the case of Mr. Guthrie, Case 4, Table III., is very striking. In both, the artery was grazed and the vein was tied; and hemorrhage from the ruptured artery occurred on the eighth or ninth day.

Case I.—On the 9th of October, 1803, a servant on board His Majesty's ship Tonnant, attempted to commit suicide. On examination of the wound, which bled profusely, it was found that the crico-thyroid membrane, the superior thyroid arteries, and the internal jugular vein had been divided, and that the outer and middle coats of the common carotid artery had been grazed. All the vessels were tied except the carotid. The ligature from the vein came away on the seventh day, the patient having progressed favourably, with the exception of a troublesome cough and some swelling of the neck, which interfered with deglutition. On the ninth day after the infliction of the wound, during a violent paroxysm of coughing, the artery gave way, and deluged the patient with blood. Mr. Fleming, although he had no precedent for the procedure, at once cut down upon the vessel below the original wound, and included it in a thread; which was removed by dissection eight days subsequently. The man was discharged well at the expiration of two months. (*Med.-Chirurg. Review*, N. S., vol. vi., 1827, p. 167.)

Case II.—Professor Greene, on the 19th of August, 1866, removed an enormous so-called bronchocele from a lady, forty-five years of age. The entire growth was covered with a network of fragile dilated veins, which poured out a fearful amount of blood on being divided. At one point the tumour adhered to the sheath of the carotid vessels; and while separating it, a gush of venous blood indicated the rupture of the internal jugular vein, which was tied at the completion of the operation. With the exception of some trouble in respiration and deglutition, the woman made an excellent recovery, the entire wound having cicatrized on the thirty-third day.[1]

The correctness of the first conclusion, that incised and punctured wounds of the internal jugular vein, when subjected to no treatment, or in which the mode of treatment is not given, and for which the ligature has not been employed, are invariably fatal from primary hemorrhage, the introduction of air, pyæmia, or secondary hemorrhage, is, with the exception of the occurrence of pyæmia, attested by the following additional cases.

CASE I.—" Wattmann gives the details of a case of a woman found dead in bed, with several incised wounds in the neck, by two of which the internal jugular vein was opened at two places. It was evident from the extent of the hemorrhage and other circumstances, that the wounds had been inflicted during life; and Wattmann endeavours to prove that it was not a case of suicide."[2]

CASE II.—Dr. Handyside reports a case of a gentleman who had cut his throat. The conjoined origin of the occipital and posterior auricular arteries, and the posterior facial vein on the left side had been divided, together with the internal and external jugular veins of the right side. A pound and a half of blood were lost. Air was found, on post-mortem inspection, in the internal jugular and thyroid veins, both venæ cavæ, and the veins of the liver, spleen, and kidneys. It was also contained in the left carotid, aorta, femoral, popliteal, and brachial arteries.[3]

CASE III.—Specimen 1521^{45} in the Museum of Guy's Hospital shows the left internal jugular vein plugged with a coagulum. It was taken from a man, thirty years of age, who had attempted suicide, and in the act, the vein had been completely divided and the thyroid gland irregularly cut. Secondary hemorrhage caused the death of the patient on the sixth day after the injury.[4]

In addition to the nine cases of traumatic communication between the carotid artery and internal jugular vein, alluded to in the January number of this Journal, there is still another example of aneurismal varia, which is peculiar from the fact of the tumour disappearing on deep inspirations. These ten instances, therefore, comprise all that have been recorded of these varieties of aneurism. The name of the gentleman reporting the case is not mentioned.

A student, twenty-two years of age, was wounded in a duel on the 29th of March, 1832, the point of the rapier having entered the neck about one inch above the middle of the right clavicle, its direction being from above downward and towards the middle line. On removing the cravat, a tumour was seen to have sprung from beneath the sterno-cleido-mastoid muscle, and a few drops of blood issued from the small triangular wound. The swelling soon became as large as an infant's head; symptoms of suffocation supervened; the pupil was dilated; and the patient lost his consciousness. These symptoms were alleviated by the abstraction of twenty-four ounces of blood from the bend of the elbow, and cold compresses were applied over the tumour.

On the following morning there were marked pulsations, and a bruit, as if fluid was escaping from a small orifice. The cold applications were continued, and on the 17th of April the tumour was reduced to the volume of an egg. Eight

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[1] New York Medical Record, Dec. 1, 1866, p. 441.

[2] Cormack's Monthly Journal Med. Sci., Sept. 1844, pp. 782-3.

[3] Edinburgh Med. and Surg. Journal, vol. xlix. p. 209.

[4] Catalogue of the Museum of Guy's Hospital, vol. i. London, 1863.